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the paper with an invitation to suggest points of revision or to add a statement to go with it. In response to this, the following comments have been prepared by Mr. Hayford. In the light of these, the review might well be modified at some points, but to avoid disturbing the basis of Mr. Hayford's comments it is left precisely as submitted.—T. C. C.

COMMENT ON THE ABOVE REVIEW BY MR. JOHN F. HAYFORD

The Report reviewed on the preceding pages by Professor Chamberlin, is essentially a preliminary statement. It was necessarily short, being one of many presented by various countries to the International Geodetic Association for publication in its triennial report. Another short preliminary statement in regard to the same investigation is also available in print, in the *Proceedings of the Washington Academy of Sciences*.¹ Both of these statements are subject to defects due to brevity. So, also, must the statement here made be brief and defective. It is hoped that a much more complete statement of the investigation may be published by the Coast and Geodetic Survey within a year from date.

The fair and clear review by Professor Chamberlin is welcomed by the undersigned. A few statements seem to be necessary, in justice to the geodetic investigation under discussion, in order that there may be no misunderstanding.

Professor Chamberlin's distinction between demonstration and interpretation, in connection with this investigation, is correct. The investigation demonstrates that the present distribution of densities follows a certain law. The statement of the meaning of this law in terms of rigidity is interpretation, and this interpretation depends, in part, on considerations outside the scope of the geodetic investigation. It seems to the writer, however, that the interpretation, given in terms of rigidity, is reasonably safe. When the interrelations of the geodetic and geologic evidence are more fully appreciated than at present, it is believed that others will reach the same conclusion.

Before discussing isostasy, it is necessary to get a clear conception of what the word means. It is stated in the review that certain language in the Report "carries the impression of a positive affirmation of liquidity or viscosusness at the base of the crust in which the differentiated densities reside. Such is the usual conception that goes with the term 'isostasy,'

¹ John F. Hayford, C.E., "The Geodetic Evidence of Isostasy, with a Consideration of the Depth and Completeness of the Isostatic Compensation and of the Bearing of the Evidence upon Some of the Greater Problems of Geology," *Proc. Wash. Acad. Sci.*, Vol. VIII, pp. 25-40 (May, 1906). The writer will be glad to furnish copies of this paper to interested persons.

as it has been used in geological literature." The language used in the Report was not intended to give the impression stated in the words just quoted. The writer, being aware that the word "isostasy" has been frequently misunderstood and used inaccurately, carefully defined it at considerable length in both his preliminary statements before the Washington Academy and the Geodetic Association. The idea of a crust composed of relatively rigid material, floating upon a liquid or viscous substratum, is not necessarily implied in these definitions. Nor is it necessarily implied in the original definition of isostasy by Dutton.¹ The floating crust represents one possible method of isostatic adjustment. Dutton does not believe in a floating crust, nor does the writer. The geodetic investigation under discussion contains strong evidence, not set forth fully in either preliminary statement because of lack of space, which is against the crust hypothesis. The condition of approximate equilibrium called isostasy may exist in materials in which there are no sudden changes in viscosity.

In his review Professor Chamberlin states that, under the accretion hypothesis, an initial arrangement of densities might be produced such that the condition of approximate equilibrium called isostasy would exist, and that therefore the present existence of isostasy does not necessarily prove anything in regard to the rigidity or lack of rigidity of the earth. The following quotation² shows that the writer recognizes that such an initial condition may have existed, but that he also recognizes that, even if it did exist, the present facts still constitute a proof of low rigidity and of isostatic readjustment:

It is possible that the continents and oceans are in their present positions because light materials accumulated at the outset in the places now occupied by the continents, and heavier material accumulated where the deep oceans now lie. This would constitute an initial isostatic adjustment. But the geologic evidence is overwhelming that within the interval covered by the geologic record many thousands of feet of thickness have been eroded from some parts of the earth, and have been transported to and deposited upon other parts. If isostatic readjustment had not also been in progress during this interval, it would be impossible for the isostatic compensation to be so nearly complete as it is at present.

The writer believes the degree of completeness of the isostatic adjustment to be a measure of the degree of effective rigidity, under forces con-

¹ C. E. Dutton, "On Some of the Greater Problems of Physical Geology," *Bulletin of the Philosophical Society of Washington*, Vol. XI, p. 53.

² Hayford, *The Geodetic Evidence of Isostasy*, p. 35.

tinuously applied for a long time, of the material composing the outer part of the earth. A flowage of rocks, of the character referred to in Professor Chamberlin's review, may be one of the ways in which the material yields to forces continuously applied for a long time, even though those forces are not sufficiently great to produce motion if applied for a short time only.

Professor Chamberlin has, in the curve *C-C*, furnished a statement of the manner of distribution of the isostatic compensation with respect to depth corresponding to the accretion hypothesis. Since writing this review, Professor Chamberlin has been assured that a sub-solution upon that basis will be added to the geodetic investigation before the final publication is made.

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The Geology of South Africa. By F. H. HATCH and G. S. CORSTROPHINE. London and New York: The Macmillan Co., 1905. Pp. 348, 2 maps, 89 figures.

The authors have attempted in this work to put within the limits of a small volume the essentials of the geology of South Africa. Their long experience in South African geology, both in the Transvaal and Cape Colony, has fitted them well for their task. The literature of South African geology is especially burdened with a great mass of semi-scientific writings which deal with isolated areas, without any attempt at correlation with neighboring regions, and only recently by the work of the Cape Colony and Transvaal surveys, has geological work been carried to a stage that would warrant the treatment of South Africa as a unit. The book contains some details that were hardly intended for the student so far away as America, and, on the other hand, many general points of vital interest are passed over all too briefly. This is especially true of the physical history and dynamical problems of the region. Nevertheless, the volume is a valuable and welcome summary of the geology of this distant land.

The "pre-Karoo" (pre-Permo-Carboniferous) rocks are treated in two sections: Section I describes those of south Cape Colony; Section II those of the Transvaal and neighboring regions. At the base, in both regions, is a series of micaceous slates and quartzites with occasional conglomerates and crystalline limestones, into which were intruded granite